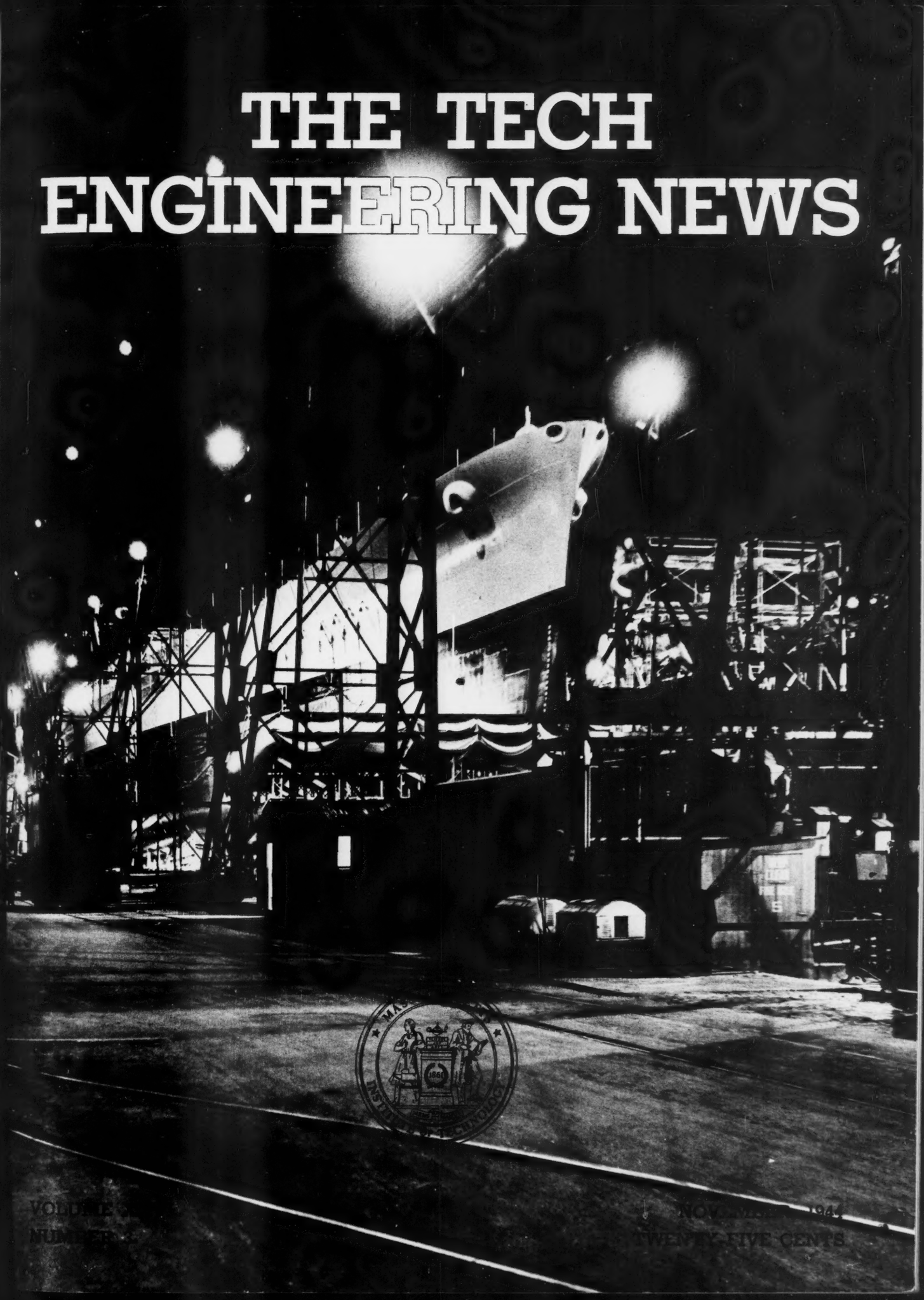
THE TECH ENGINEERING NEWS



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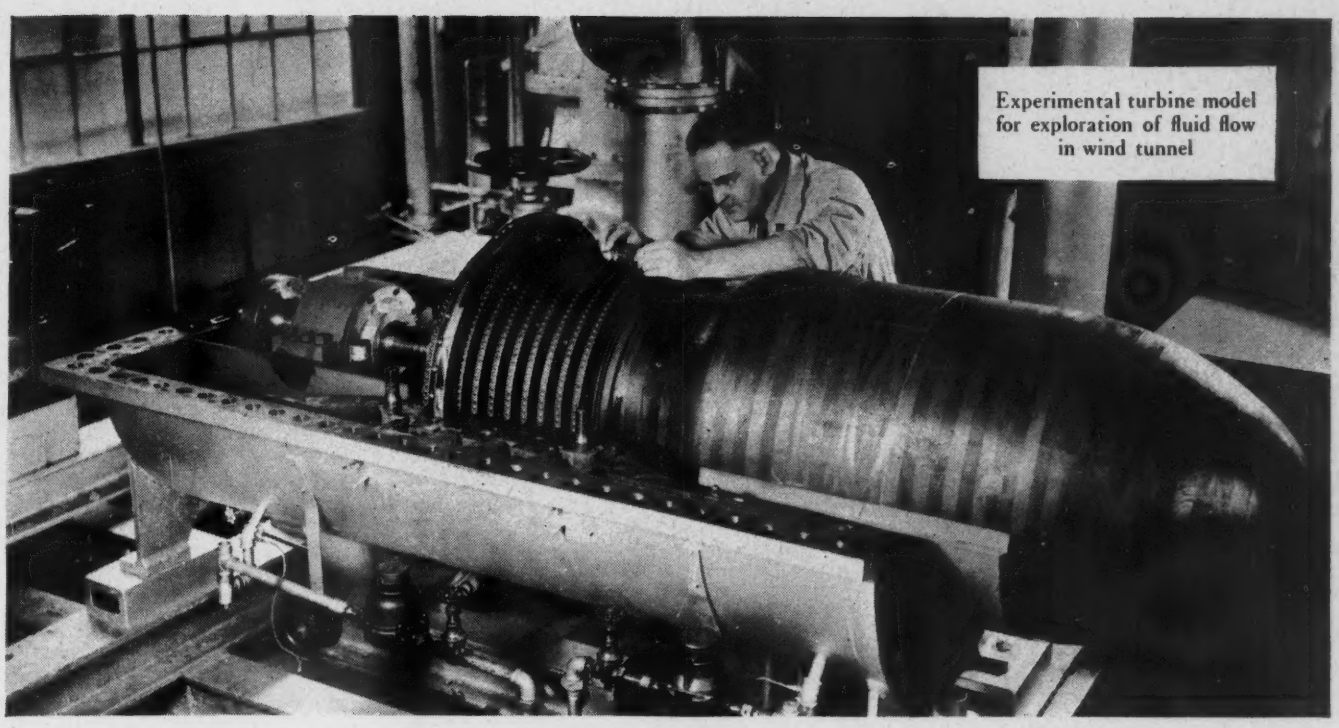
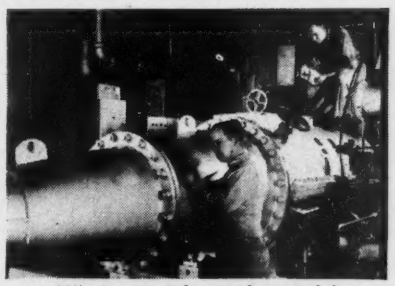


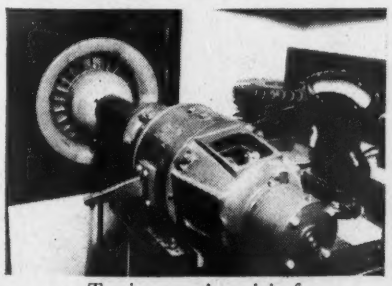
Experimental turbine model for exploration of fluid flow in wind tunnel

OPPORTUNITIES for Creative Junior Engineers to work on research and development of Gas Turbines



Wind tunnel for testing model shown above

Photoelastic study of loaded turbine blade root



Testing wood model of axial flow compressor

Here is an opportunity to get in "on the ground floor" in the new gas turbine industry which promises to revolutionize transportation motive power on land, at sea, and in the air.

Westinghouse needs many graduate engineers with training in engineering mathematics, mechanics, thermodynamics, aerodynamics, metallurgy, or combustion engineering.

Young men with technical training will find an outlet for their creative ability in the research and design of gas turbines and their component parts.

Here are typical activities: Flow research on bladed compressor and turbine structures, diffusers, and nozzle passages—theoretical analysis of gas turbine cycles—study of vibration and stress problems—combustion chamber design and research with all fuels—research and performance testing of the finished product.

Graduate engineers selected by Westinghouse will work in modern laboratories in the Philadelphia area—completely equipped with the finest of research and testing facilities and coordinated with the Westinghouse Research Laboratories at East Pittsburgh, Pa.

If *you* are interested in associating yourself with the new gas turbine industry, secure a Westinghouse Application Blank from your Dean of Engineering and mail it promptly to: Supervisor, Technical Employment, Westinghouse Electric & Manufacturing Company, 306 Fourth Ave., Pittsburgh 30, Pa.

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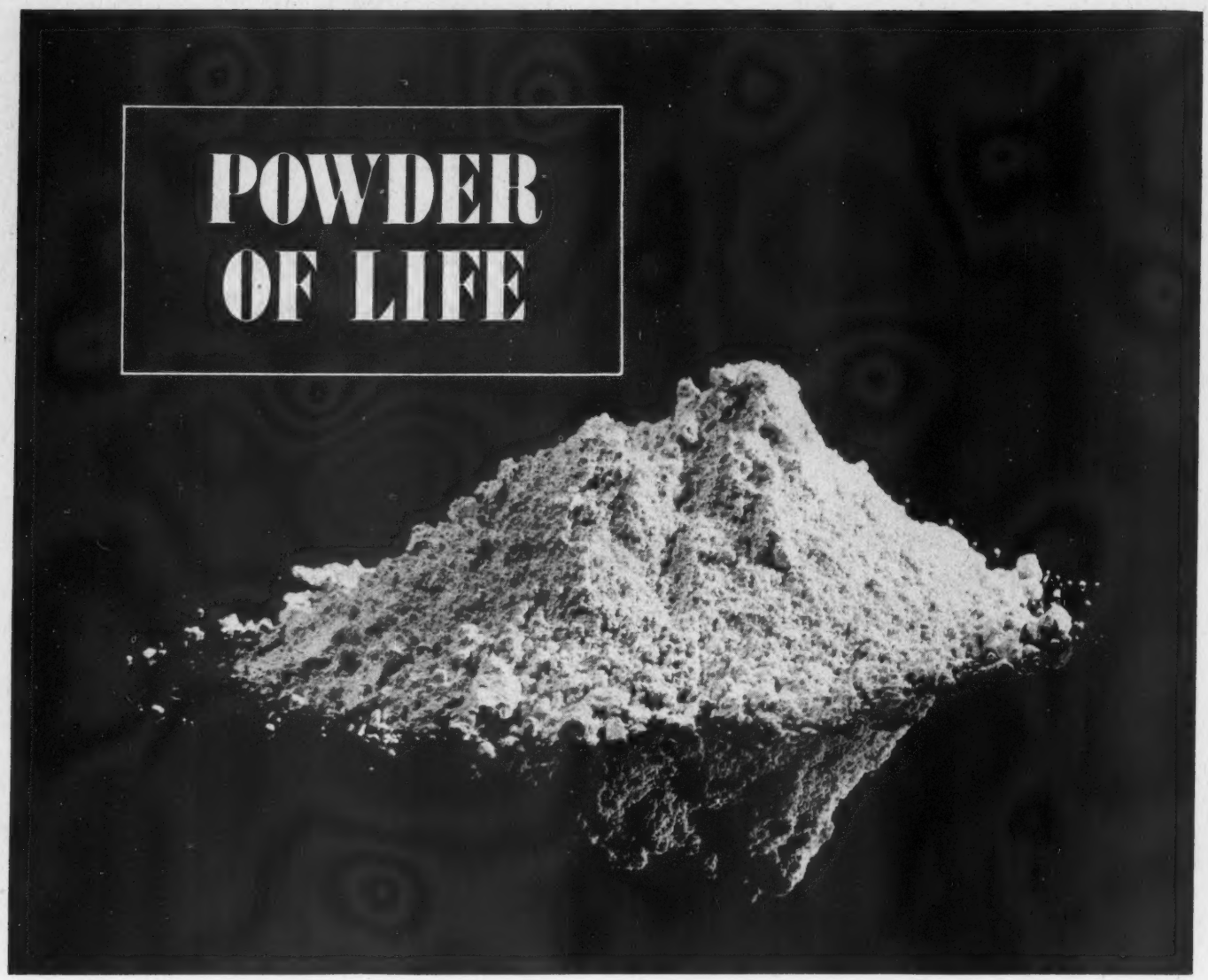


This is a handful of penicillin.

Yesterday it was amber drops of liquid excreted by *penicillium notatum* or common mold.

Today it is a powder ready to be shipped to some battlefield.

Tomorrow it may save a life.

In a great measure the triumph of penicillin is a triumph for air conditioning and refrigeration.

At Cheplin, Hayden, Lederle, Pfizer and Reichel —mass producers of penicillin—York-built air conditioning systems keep the nurturing tanks at just the right temperature for proper growth.

After the golden drops are extracted from the parent mold, York refrigeration takes over.

The liquid penicillin is frozen enabling evaporation to take place in a high vacuum at temperatures low enough to keep alive the bacteria-killing properties of the drug. The result is the stable powder that you see above.

Although penicillin has been put on a mass production basis, research still goes on. Scientific medicine will certainly discover new types of disease-killing molds and develop new and better methods of production.

Just as certainly the science of cooling will match their efforts with the necessary equipment to perform the tasks they require.

York Corporation, York, Penna.

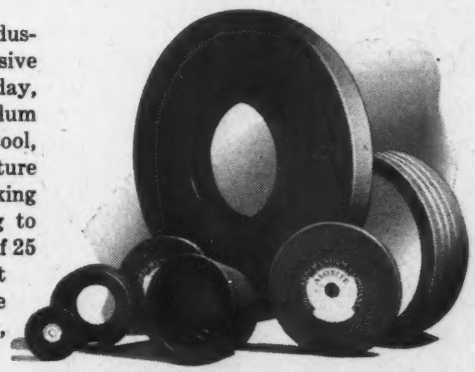
YORK REFRIGERATION AND AIR CONDITIONING

HEADQUARTERS FOR MECHANICAL COOLING SINCE 1885

The plane that had its face lifted!

The B-25 Mitchell bomber has always been a tough baby. And when they lifted its face and gave it a 75 mm. gun for a nose, they made it even tougher! There was only one drawback: *Quantity production* of that special cannon. It might have been serious—if a foundry hadn't found out how to *cast* the cannon breech rings instead of machining them. And here Carborundum played an important part by supplying the right grinding wheels to improve and speed up production of these rings.

It was more than fifty years ago that industry bought its first manufactured abrasive grinding wheel from Carborundum. Today, industry uses abrasives by Carborundum everywhere from foundries, machine tool, aviation and automobile plants to furniture and shoe factories. That is why a working knowledge of abrasives is a good thing to have. Write us today for a complete set of 25 free bulletins on the First Principles of Grinding. The Carborundum Company, Niagara Falls, New York.



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OWI Photo by Palmer, in an Allegheny Ludlum plant

Steel Man with a Mission

. . TO KEEP THE ELECTRIC FURNACES MELTING

ALL of us, men or women—on the job or off it—are people with a mission these days. The war makes common cause for every one and spares no one.

This maintenance man's job, atop an Allegheny Ludlum electric furnace, is no less essential than that of the crew who operate the furnace, nor than that of the men in the factories who use the stainless, tool, valve or electrical steel it produces. Total war requires maximum cooperation on the supply fronts as well as the fighting fronts, and it asks also that every last bit of manpower and materials be used to the maximum advantage.

Boiled down to a very few words that simply means: *no waste—everybody help.* It means, in terms of your everyday life, using everything wisely to secure the most wear; reducing expenditures to a minimum; saving materials; buying War Bonds and stamps to the limit.

It also points up a responsibility that falls upon you as one of the next generation of business men and technicians. War is the ultimate waster of men and materials, but it brings about enormous technical progress and development. That has been very true in the special steel fields. It will be yours to translate these advances into terms of better living.

Allegheny Ludlum
STEEL CORPORATION
BRACKENRIDGE, PENNSYLVANIA

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Twin Cities Zephyr along the upper reaches of the Mississippi

Trains for the Modern World

There are two Twin Cities Zephyrs in the fleet of fourteen stainless steel streamliners serving fortunate cities on the Burlington Lines. Every day, each way, they provide a swift and comfortable daylight trip between Chicago, St. Paul and Minneapolis.

Stainless steel was chosen for these and other Budd-built trains because it has the most desirable combination of physical properties of any known metal suitable for structural purposes. It is the strongest. It has the highest resistance to impact or fatigue. It is non-corrosive. It is the only metal which can be toughened by welding. It resists abrasion better than any other. Fabricated by the patented SHOTWELD* system, Budd stainless steel trains represent the highest standards of strength and safety.

For nearly three years, Budd facilities have been wholly employed in war production. When men and materials are released from that task, new trains of stainless steel, embodying still more modern ideas of travel luxury and convenience, will roll from the Budd shops, for service on American railways.

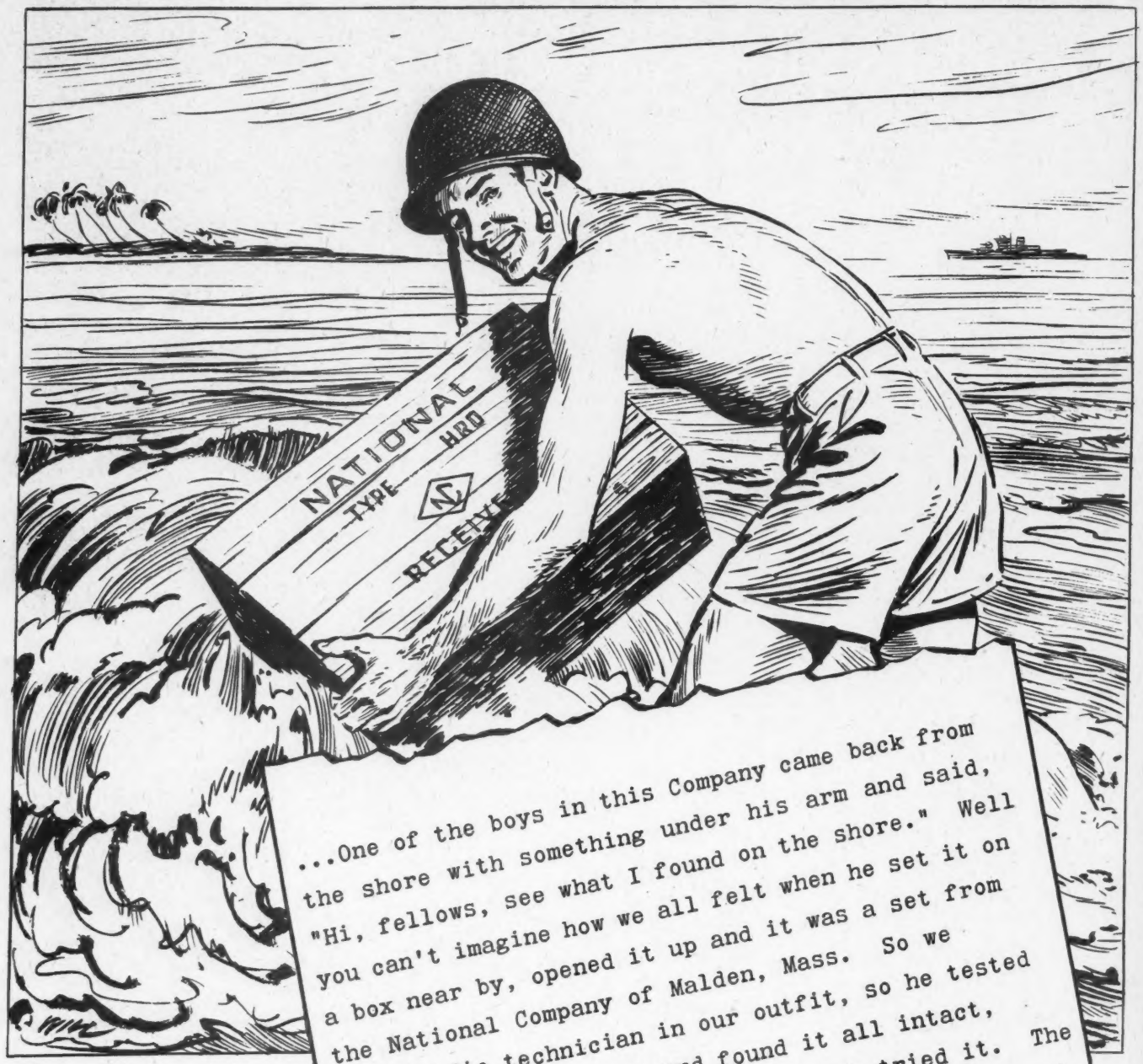
EDWARD G. BUDD MANUFACTURING COMPANY
PHILADELPHIA • DETROIT

Originators of ALLSTEEL* *auto bodies, stainless steel lightweight trains and highway truck trailers. Designers and makers of airplane and marine structures. Inventors of the* SHOTWELD* *system of fabricating hi-tensile steel.*

REG. U. S. PAT. OFF.

Budd

"HI, FELLOWS, SEE WHAT I FOUND"



...One of the boys in this Company came back from the shore with something under his arm and said, "Hi, fellows, see what I found on the shore." Well you can't imagine how we all felt when he set it on a box near by, opened it up and it was a set from the National Company of Malden, Mass. So we had a Radio technician in our outfit, so he tested it, looked it all over and found it all intact, closed it up again, grounded it, then tried it. The salt water had not hurt it one bit—it gave us grand reception and each night, we, or about 12 of us, listened in and it seemed like a message from home.

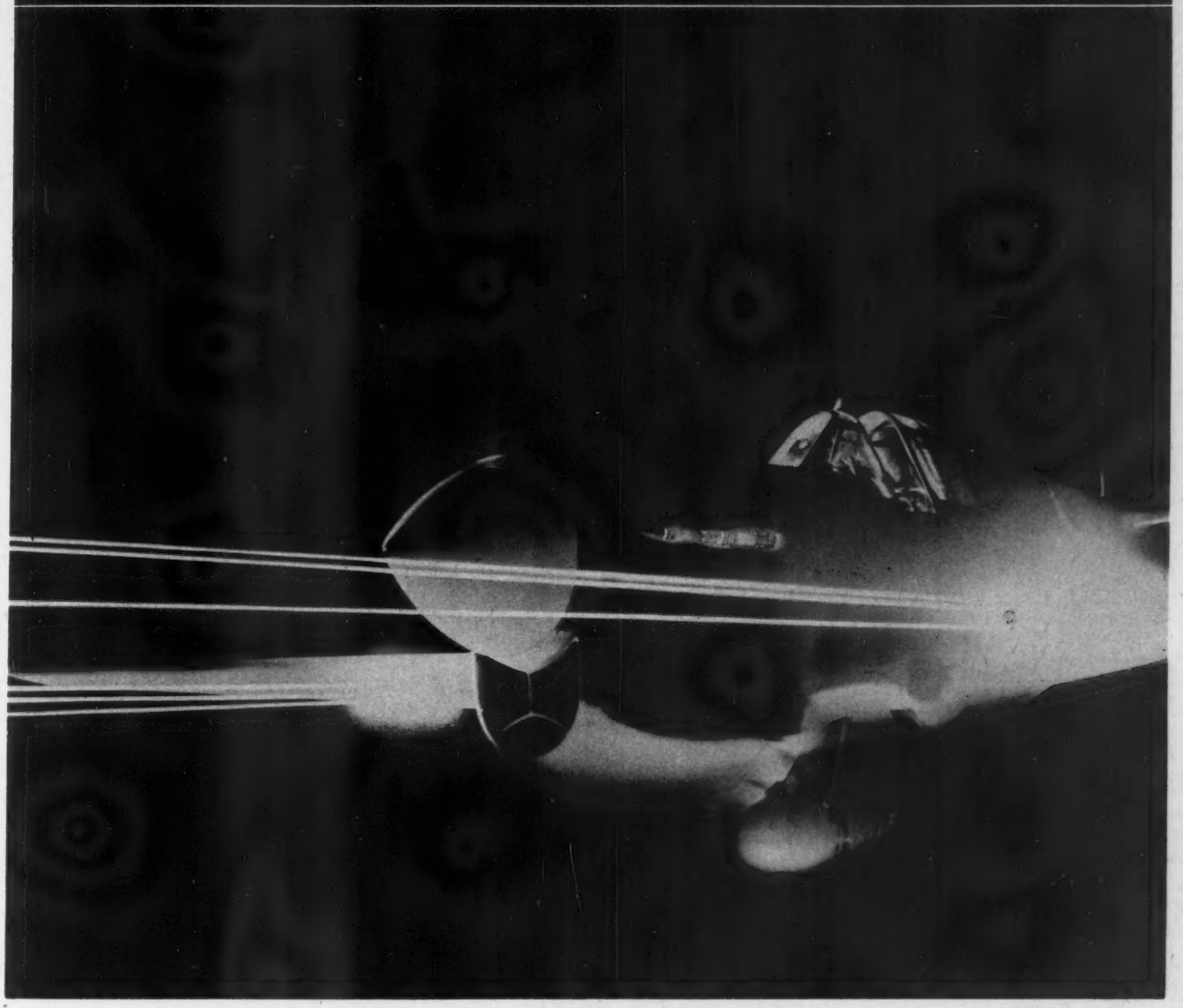
(Excerpt from a letter we received from a soldier in the Pacific.)

NATIONAL COMPANY, INC.

MALDEN MASS, U. S. A.

NATIONAL RECEIVERS ARE IN SERVICE THROUGHOUT THE WORLD

The glass that breaks over Germany...



YOU'VE seen pictures of long range fighter planes with their "belly tanks" that carry extra gasoline. But have you ever wondered how the pilot gets rid of those tanks when they're empty, to decrease weight and gain extra speed and maneuverability?

The big problem in dropping the tank is to sever a tight pipeline connection from tank to plane quickly and positively. This isn't easy with metal, but Corning now makes a fitting from glass tubing that does the trick. The minute the pilot releases the mechanical grips that carry the weight of the tank the glass tubing breaks cleanly and the tank falls free!

War and Corning Research have put glass in a lot of strange places. For instance, there was a time when almost all piping in chemical plants was alloy of one kind or another. Now chemical people have discovered that glass piping is better for many purposes, and Corning has even developed a method for welding it into continuous lengths.

Many of the new uses to which Corning has put glass will persist after the war. For many users have discovered for the first time how really versatile glass is as a material. They are finding out that it has unexpected strengths. That it resists abrasive wear and corrosion. That it is so fatigue proof Corning has even made springs of coiled glass for certain conditions. Perhaps after the war, in whatever business you choose to follow, you will also find that an intelligent application of glass can improve your product or production — Corning Glass Works, Corning, New York.

CORNING
means
Research in Glass

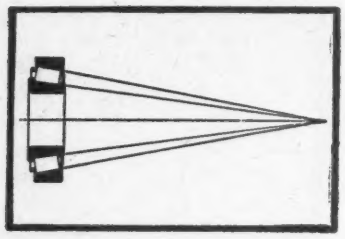
WHAT YOU SHOULD KNOW ABOUT THE TIMKEN BEARING

DESIGN

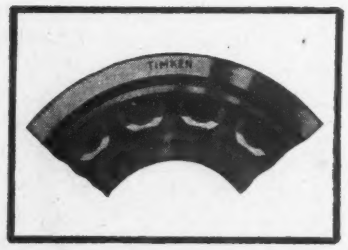
Essence of Performance

Timken introduced the tapered principle over 45 years ago to obtain an anti-friction bearing with the ability to carry radial loads, thrust loads or any combination of the two. During the ensuing long period of engineering development and experience, a constant refinement of design has taken place, making the Timken Bearing of today supreme in performance.

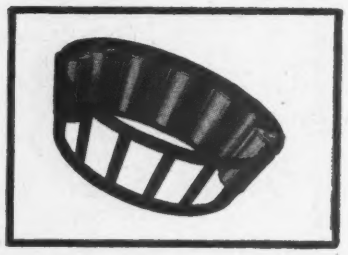
Here are the three most important features exemplified in the design of the Timken Bearing.



1. TRUE ROLLING MOTION: This basic necessity is assured by making all lines coincident with the tapered surfaces of the rollers, cup and cone, meet at a common apex on the axis of the bearing, Figure 1. True rolling motion always has been incorporated in the Timken Bearing.



2. POSITIVE ROLLER ALIGNMENT: During the development of the Timken Bearing, as speed, load and accuracy requirements increased, various methods were used to stabilize the rollers and prevent them skewing in the raceways. The solution was found in establishing wide-area contact between the large ends of the rollers and the undercut rib of the cone, thus assuring constant and accurate roller alignment around the periphery of the raceways. The light areas on the ends of the rollers in Figure 2, show contact of rollers with undercut rib of cone.



3. MULTIPLE PERFORATED CAGE: All the openings in the Timken Bearing cage, Figure 3, are stamped out in one operation by means of multiple perforating dies made to extremely close precision tolerances. This assures exact center-to-center spacing of the rollers around the periphery of the raceways, so that every roller takes its full share of the load when the bearing is in operation.

A thorough knowledge of Timken Bearing design and application will be one of your best assets when you graduate to enter the professional engineering field. Begin to acquire it now. The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS

THE TECH ENGINEERING NEWS

PROFESSIONAL JOURNAL OF THE UNDERGRADUATES

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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NOVEMBER 1944

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THIS IS M. I. T.

METALLURGY

By ROBERT S. WILLIAMS
Professor of Metallurgy

LONG before any recorded history, a stone age man probably built a little wall of loose rocks to shield his fire from the wind and by accident picked up a bit of copper ore as one of his building blocks. The heat of the fire and the charcoal from the burned wood changed the ore into metallic copper and the prehistoric man found in his pile of rocks a reddish material with properties very different from the stones he had used. He or one of his more inquisitive neighbors found that the material could be worked into various shapes and was much more useful to him than the flint that he had fashioned so laboriously into crude tools and weapons. From this simple metallurgical discovery man over the centuries has improved the stone man's methods until he now produces steel in furnaces making three hundred tons in a single heat.

Metallurgy, then, is one of the oldest of the arts. In the first chapter of Genesis, Tubal Cain is described as an "Instructor of the artificers of metals." While the records of the archeologist and geologist are not wholly clear in prehistoric times, the evidence seems convincing that gold was fashioned more than 4000 years B. C. and perhaps 8000 or 10,000 years. Well established associations show a knowledge of silver and copper as far back as 3000 to 4000 years B. C., iron at least 2500 B. C. and a few metals like tin, antimony and mercury from 1000 to 2000 years B. C.

Down through the ages the metallurgist was primarily interested in the production of metals from their ores and alloys were usually made accidentally or incidentally. The early history of metallurgy like that of chemistry is associated with the work of the alchemists and, while many discoveries were made in the alchemical period, it is difficult now to separate science from mysticism.

Modern metallurgy as a science rather than as an art had its beginnings shortly after the time of Lavoisier and the early chemists. Moderate improvements in the smelting and refining of ores took place during the first half of the last century, with the increasing knowledge of chemical reactions culminating about the middle of the century with the invention of the Bessemer process in 1855 and the open hearth process a few years later. These inventions mark the beginning of our modern Age of Steel.

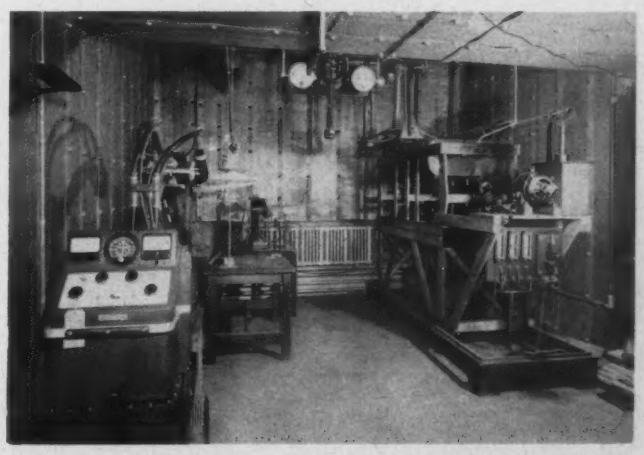
Alloying, too, is a very ancient art, as records exist of the alloying of gold and silver to make "white gold" perhaps 3000 years B. C. But again the making of alloys was an art and not a science. While some attempts at a scientific approach to the technology of alloys was made during the years following the inventions of the steel making process, it is generally conceded that alloying as a true science really began about 1890 with the adaptation of the microscope to the study of metal structure. The possibilities of scientific development through the use of the microscope were at once recognized by a group of pioneers including such men as Osmond in France, Stead in England, Howe (M. I. T., 1871) and Sauveur (M.I.T. 1889) in this country. The outstanding contributions of this group soon led to a division of the science of metallurgy into two major subdivisions: process or production metallurgy and physical, adaptive or use metallurgy. Although the line of demarcation between the two fields is by no means sharp and is constantly broadening, it is generally agreed today that the production metallurgist is primarily concerned with the reduction and refining of the ores to produce metals, essentially a series of chemical operations, while the physical metallurgist is mainly concerned with the properties and uses of the metals produced, either as received or in the form of alloys. His methods, then, are more closely related to physics than to chemistry, as he uses the microscope, the electron microscope, the X-ray, mechanical testing devices, the spectrograph and the like in his studies.

The whole field of Metallurgy, then, requires sound knowledge of several related sciences so that the Institute course in Metallurgy includes basic training in chemistry, physics, mathematics and those cultural courses like English, history and economics that are essential to the training of any man no matter what his profession. Specialization begins in the third year but, since it is usually not possible at that time to determine

(*Continued on page 84*)

Pouring a heat of steel into ingot molds
Bethlehem Steel Company

General view of lead-lined X-ray exposure room containing 150 kv and 300 kv units



GAS TURBINES—FUTURE POWER

By SIDNEY L. SMITH, JR., 2–47

THERE has been much discussion in engineering circles recently of the newest of the prime movers — the gas turbine. Actually, it is erroneous to call this engine the "newest" since the idea or general theory behind the gas turbine has been in evidence in the minds and sketch-books of inventors for hundreds of years. Only with the advent of our modern aeronautical and metallurgical concepts, however, has this idea of a gas turbine become a practical possibility.

At present, with many and varied fields in which the gas turbine may play an essential role, its development and applications are proceeding at an increasingly fast rate. If its capacities meet with some of the predictions made for it, the gas turbine may truly result in a revolution in power generation.

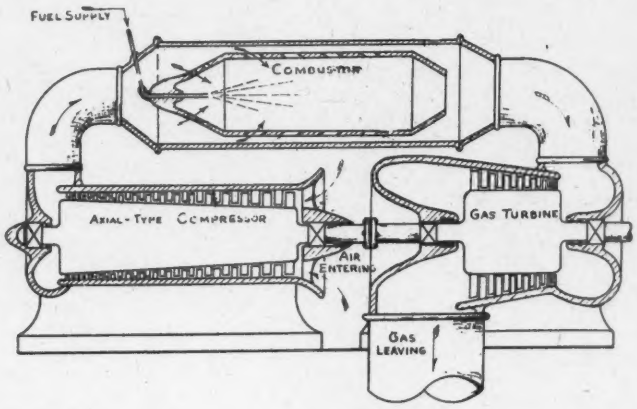
History and Development

The development of the gas turbine previous to the last decade was slow and at times very discouraging. A number of gas turbines of various types were actually constructed, but in all cases it was found that their efficiency could not be made high enough to produce any power for outside use. In fact, in some cases, more work was put into the machine than could be gotten out.

Dr. Sanford A. Moss, long associated with gas-turbine development, writes this account of his early experiments:

"The author always has had in mind continuous combustion, and . . . he started gas-turbine research in 1901, in the Sibley College Laboratory, Cornell University. Laboratory time for a year was required to get a continuous-combustion chamber in stable operation."

Dr. Moss, then at Cornell, borrowed a bucket wheel from a steam turbine and operated it with a combustion chamber. In this experiment as in the others, however, it was found that the turbine was so inefficient that it was impractical at that time. This experiment, and



Gas turbine cycle major elements *Westinghouse*

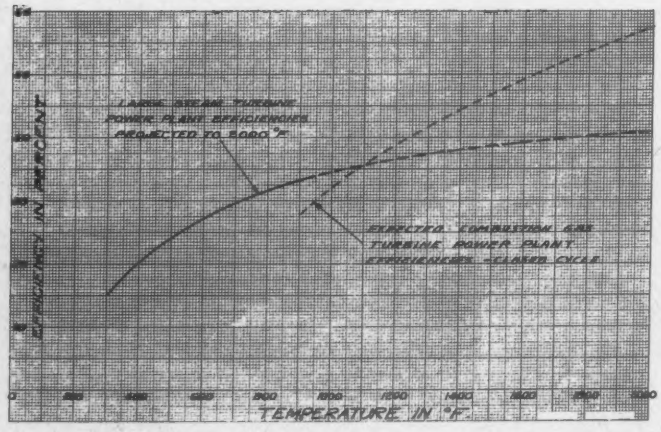
those like it, though they did not produce immediate results, did lay the foundation for the gas turbine's present success and acceptance as an important prime mover.

The Swiss expert on turbines, Dr. Aurel Stodola, who died recently, predicted of the gas turbine as early as 1905:

"As the steam turbine, without bringing an actual betterment of steam economy, has entered into the industry because of its constructive simplicity, so will it be with a gas turbine, which is constructively simpler than the gas motor, provided it will only exceed the steam motors in efficiency . . . but only when the mechanical efficiency of the compression reaches an exceedingly good value, and when the utilization of the flow energy in a turbine has been considerably increased, or when substances have been found of sufficient stability beyond red heat, will the gas turbine be taken up in the industrial world."

In 1926, Dr. Stodola "proved" mathematically that the gas turbine would never become efficient enough to compete with other prime movers. But according to a contemporary account, in 1936 the same man actually ran the efficiency and acceptance tests on the first gas turbine power unit and had the scientific integrity, courage, and grace to admit his error and approve the unit wholeheartedly.

Curves comparing efficiencies of best practical steam power plants and combustion gas turbine plants *Westinghouse*



Construction and Operation

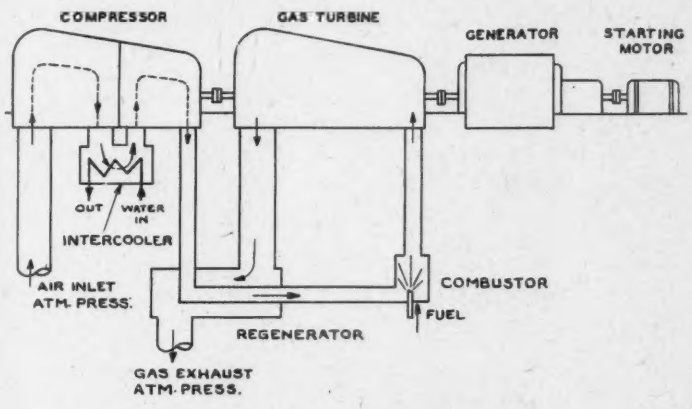
The gas turbine is really much simpler than any of our other power generators. Essentially, it consists only of an air compressor, a combustion chamber with some sort of fuel feed, and the turbine rotor itself. This is the basic gas turbine cycle. Large volumes of air are compressed and then burned with some sort of fuel (only liquid fuels have been used with success so far) in the combustion chamber; the expanding gases resulting from this combustion whirl the turbine rotor as they pass from the engine. The turbine wheel is on the same

shaft as the compressor and thus supplies the energy needed for air compression. The net power taken from the gas turbine is obtained either by gearing the shaft directly, or by getting electrical power from a generator on the shaft.

The theory behind gas turbine power may be said to be basically this: Products of combustion, containing 300 to 600 per cent excess air, expand through turbine blades to atmosphere. Since more work is available from the expanding high-temperature gas than is required for the low-temperature compression, the turbine has an excess of power available for a generator or for mechanical power.

The speed of the turbine is controlled simply by regulating the rate of fuel supply. There is no need for governing valves as in the case of the steam turbine, though an emergency outlet valve may be put on the combustion chamber so that the power generation can be stopped immediately if need be.

Most of the modern gas turbines utilize the axial compressor, which is constructed on air-flow principles developed from the research in aeronautical design during the past years. In fact, the discovery of this



Open cycle with intercool and regeneration *Westinghouse*

efficient type of air compressor might be said to be one of the chief factors which made possible the present practicable operation of the gas turbine.

The efficiency of the gas turbine is also greatly affected by the operating temperature, the trend being increased efficiency with rise in temperature. Thus an overall turbine efficiency of 18 per cent at 1000° F. rises to approximately 22 per cent at a temperature of 1200° F., which is apparently the top practical limit of the forged alloy steel rotor blades used in existing gas turbines. Higher temperatures (some as high as 2000° F.) have been reached in airplane turbosuperchargers, where military necessity places more emphasis on immediate performance than on long wear. But 1200° F. is the highest practical operating temperature of commercial gas turbines at the present time.

The simple gas-turbine cycles already described can be made more efficient by the addition of various types of auxiliaries. One of the most common is a regenerator or heat-exchanger, by means of which the heat of the exhaust gases from the turbine is used to preheat the compressed air before it enters the combustion chamber. In some cycles, two compressors are used and the incoming air is cooled before compression. Some cycles use a second combustion chamber and turbine.

Present and Future Applications

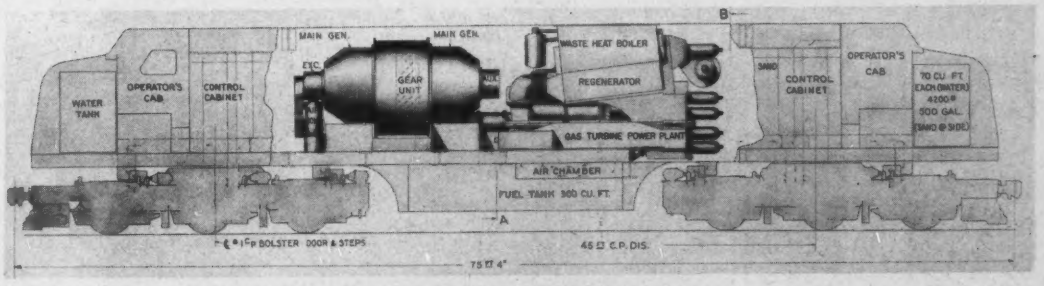
Possibly the earliest general application of gas-turbine principles was the installation of turbosupercharges by the United States Army Air Forces. Dr. Moss writes: "The principal interest that the turbosupercharger has in connection with the gas-turbine problem is its development of a turbine to operate at high temperatures of products of combustion. It is true that the aviation turbosupercharger has only short-time operation at extreme conditions, and does not have to meet the conditions of continuous operation in a power plant. Nevertheless, many problems have been solved, due to the impetus of World War II, which advance the prospects of a gas turbine as a prime mover. Thus, the turbosupercharger, originally a gas-turbine by-product, not only has proved very useful of itself, but has accelerated gas-turbine development."

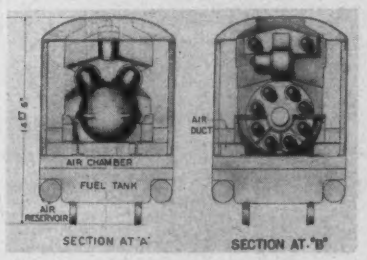
The outbreak of the present war prevented some American application for power-generating units from becoming a reality. The only plant we have test information on at present is the gas turbine built by the Brown, Boveri Company of Switzerland to supply electric power to the city of Neuchatel in that country. The successful results of this experimental unit were what finally convinced Dr. Stodola and many others that gas-turbine power was a practical possibility. The advantages of gas turbines over other prime movers are simplicity in mechanism and consequent cheaper initial costs of installation and maintenance.

At present more than 90 per cent of all stationary thermal power plants in the United States and nearly 100 per cent in many other countries are burning coal. Attempts have been made to adapt the gas turbine to solid

(*Continued on page 86*)

Combustion gas turbine locomotive *General Electric Company*





TRIPTANE AND THE ENGINE TODAY AND TOMORROW

By HENRY L. LEE, 2–47

IN the internal-combustion engine lies one of our greatest sources of power. The amount of horsepower generated by the engines of our automobiles and airplanes is many times that of our central power generating stations. The total horsepower of the airplane engines made for war in a single month exceeds by 1,000 per cent the amount generated by Boulder Dam. These engines are our main source of power for transportation, and are subject to a vast amount of research aimed at increasing their efficiency. This research is carried on mainly by the two chiefly concerned industries, the automobile manufacturer and the petroleum refiner.

The power output of an internal-combustion engine is dependent upon two factors, the fuel used and the design of the engine. The purpose of an engine is to release as much of the chemical energy of the fuel as possible and to convert it to mechanical energy. It is able to do this because of the large force of expansion of a gaseous or vaporized fuel which has been ignited. The greater the expansion force, the more power. The expansion force is greatly increased by compressing the vaporized fuel prior to ignition. Here lies the greatest obstacle to increased efficiency. The fuel may be compressed up to a certain point, called its critical compression Ratio, after which there arises a combustion disturbance called knock, which prevents any further increase in efficiency. If the critical compression Ratio of the fuel is greatly exceeded, the destruction of the engine results. Diesel engines are well known for their high efficiency because of the high compression ratios of their fuels, but the weight of the Diesel prevents its general use in light vehicles. Thus, if the efficiency of the engine increases with the amount of compression, but decreases with an increase of knock, the prevention or overcoming of knock leads to a more efficient engine.

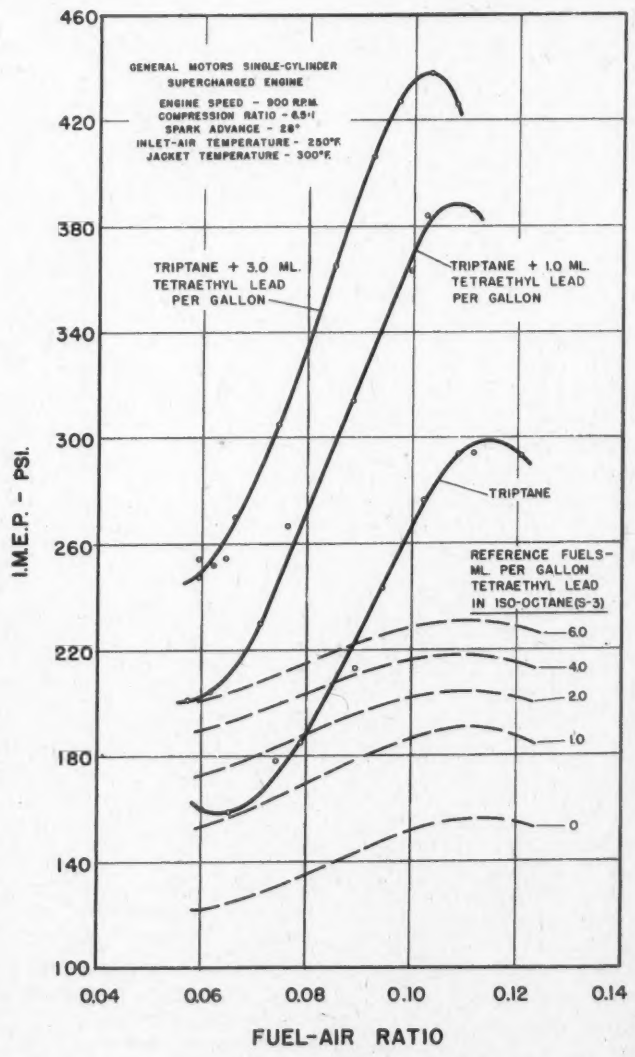
What actually happens when combustion takes place is but poorly understood. It is a chemical reaction, but usually not a simple one. Despite the lack of an exact knowledge of combustion, two ways of lessening knock have been found. The first and heretofore commonest means has been the addition of certain antiknock chemicals to the fuel. These compounds enable the fuel to be compressed to a greater degree before the occurrence of knock. The commonest of these antiknocks are aniline and tetraethyl lead — the latter being in almost universal use. Just what these compounds do to the fuel so that it performs better is not understood, but they have helped tremendously.

The second and most recent method of bettering the performance of the engine has been the result of a more careful study of the molecular structure of fuels and their respective performances. A comparison of the molecular structure of various fuels with their relative performances has revealed interesting and helpful facts. Those fuels having short, compact structures have shown less tendency to knock than the fuels with long, chainlike structures. The family of heptanes has been most interesting in this regard. Besides containing many fuels better than iso-octane, which is used as a standard — 100 octane, it contains a fuel of compact molecular structure which has performed three times better than iso-octane, and which, upon the addition of tetraethyl lead, has given performances beyond many common methods of measuring an engine's output. This amazing fuel is called triptane or 2, 2, 3-trimethyl butane.

Triptane was first made as an individual chemical compound by Chavanne, a Belgian, in 1922. It was again made by the Ethyl Gasoline Corporation and

Knock limited power curves for triptane

General Motors Corporation



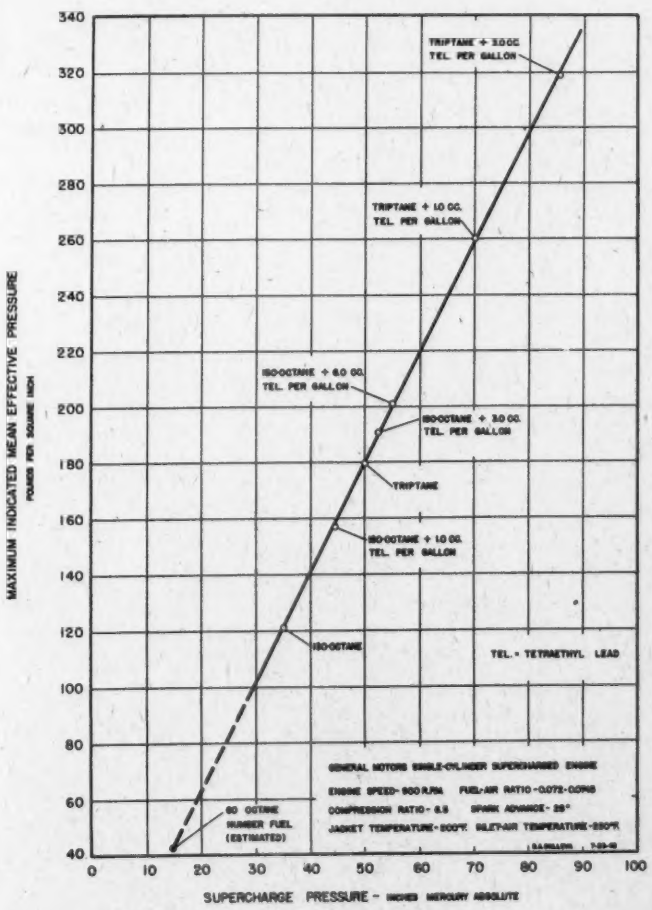
first tested in a gasoline solution in an engine in 1926. Slightly later the General Motors Research Laboratories pronounced it to be one of the more outstanding fuel components. But triptane suffered from the limitation that it could not be made cheaply, and as a result little was done in connection with it. About 1939, some 300 gallons of the compound were prepared by the Dow Chemical Company for the Ethyl Corporation by a rather laborious procedure involving the use of metallic magnesium — the final cost being about $35 per gallon. The triptane so produced was subjected to various engine tests in many laboratories. It was tested at Wright Field in 1941 in a large aircraft engine, and was found to be superior to any other fuel previously tested. Because of the cost of the fuel, further tests were held in abeyance.

After much research, a method for producing pure triptane at a comparatively lower cost was found. Still more recently, a still cheaper process has been introduced, but the cost today is still slightly above that of the more common fuels. Following the development of the first process, several tank car quantities were prepared and more extensive tests were made in order to obtain enough data to evaluate comprehensively the possibilities of triptane as a fuel, either pure or blended with other fuels. These tests again demonstrated some remarkable gains in the power output of engines. Using triptane and the antiknock compound, tetraethyl lead, the power output was four times greater and the gain in fuel economy up to 25 per cent more than that of 100-octane gasoline. Great possibilities of triptane as a commercial fuel were shown.

During the tests, however, such favorable results were not obtained when the engine was operating under extremely severe conditions. This fact emphasized the part played by the engine. The engine must be designed for the fuel it is to use. Obviously, the engines were not designed to get the most out of triptane; but with the barrier of knock removed to such a large degree, engineers are able to go ahead in engine designing. Previously, tests in engine design could not be properly made and evaluated because the part played by the fuel was uncertain.

Studies are under way to evaluate the commercial possibilities of triptane and related compounds, with the belief that the value of the fuel will justify the present projected cost per gallon, which is high when compared to fuels of lower quality. These studies do include the redesigning of engines and a study of just what may be done with engines and their applications to various uses. The problem now remaining to research is the cheap production of the fuel and a redesigning of the engine.

Performance of fuels *General Motors Corporation*


MAXIMUM INDICATED MEAN EFFECTIVE PRESSURE
POUNDS PER SQUARE INCH
SUPERCHARGE PRESSURE - INCHES MERCURY ABSOLUTE
TRIPTANE + 3.0 CC. TEL. PER GALLON
TRIPTANE + 1.0 CC. TEL. PER GALLON
ISO-OCTANE + 6.0 CC. TEL. PER GALLON
ISO-OCTANE + 3.0 CC. TEL. PER GALLON
TRIPTANE
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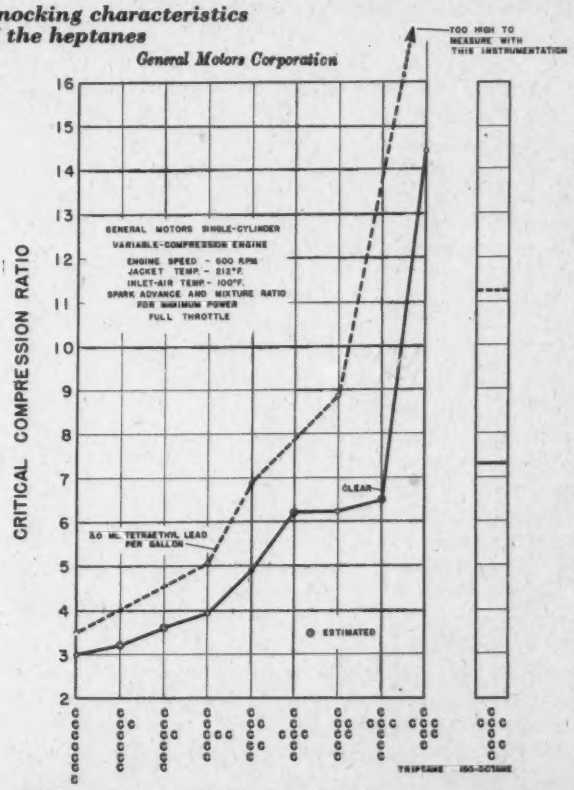
ISO-OCTANE
TEL. = TETRAETHYL LEAD
60 OCTANE NUMBER FUEL (ESTIMATED)
GENERAL MOTORS SINGLE-CYLINDER SUPERCHARGED ENGINE
ENGINE SPEED- 900 R.P.M. FUEL-AIR RATIO - 0.072 - 0.076
COMPRESSION RATIO - 6.9 SPARK ADVANCE - 25°
JACKET TEMPERATURE - 200°F. INLET-AIR TEMPERATURE - 250°F.

Knocking characteristics of the heptanes *General Motors Corporation*



With such new fuels and with engines accordingly redesigned, many desirable changes can be made in the designing of automobiles. The amount of power needed by the average passenger car is now small, and will remain so, because of better highways. Thus, if a new engine generates more power per unit than former ones, smaller engines may be used to do the same amount of work and thus reduce the size, weight, and cost of the engine. Just what the automobile industry intends to do when it starts to manufacture automobiles again, is uncertain; but the next decade does provide splendid opportunities for large-scale adoption of proven developments.

CENTER SPREAD

Another completed B-29 Superfortress is towed into the night from the final assembly line at the Boeing-Wichita plant. Engineers provided 300-foot wide spans beneath which these new war birds travel, two abreast. This huge door is one of several like it at this plant, where modern fluorescent and mercury vapor lamps turn night into day. *The Austin Company*

FOURIER DIVISION

By LAWRENCE NORWOOD
Department of Mathematics, M. I. T.

The most burdensome of all arithmetical processes is that of long division, especially when the divisor contains a large number of digits. Yet there are times when division is necessary, slide rule accuracy will not suffice, and more accurate computing instruments are not at hand. The following is a method of long division — one which obviates a large part of the arithmetical procedure of ordinary division but yet is completely accurate to as many places as desired. The rules which are given here might appear irksome and troublesome at first but with a half-hour's practice will be as easy to apply as the ordinary method. The name of Fourier is given to this method, though he himself never published it. The first description of it, by a pupil of Fourier's, appeared in a mathematical journal in France but attracted no notice. It reappeared at one time in a little-known Russian mathematical publication.

The name of Jean-Baptiste-Joseph Fourier, which is attached to this process, is familiar in its connection with Fourier series, important in mathematical physics in the treatment of the theories of heat, sound, and fluid motion. His "Theorie Analytique de la chaleur," developing the use of trigonometric series from "Fourier's Theorem," was a landmark in its field, described by Lord Kelvin as "a great mathematical poem." The son of a tailor and orphaned at the age of eight, Fourier was educated in a Benedictine military school. He reached maturity at the time of the French Revolution and as an enthusiast for that Revolution helped found the noted Ecole Polytechnique in Paris. Accompanying Napoleon to Egypt, he led the French-created Egyptian Institute in an attempt to introduce science into that land.

After his return to France he became prefect of the department of Isere with headquarters at Grenoble. His principal achievement in his political career was the subduing of political opposition by the discovery in a pious community of a saint among his ancestors. Fourier's experiences in Egypt were responsible for a curious habit which may have hastened his death. Desert heat he believed was the ideal condition for health. In addition to swathing himself like a mummy he lived in rooms which his uncooked friends said were hotter than the Sahara Desert. Through his achievements Fourier belongs to that select company of mathematicians whose work is so fundamental that their names have become adjectives in every civilized language.

ORDINARY long division presents no difficulties as long as the divisor does not exceed four or five digits. If the divisor, however, contains say fifteen or twenty digits, it becomes then rather a tedious business to perform multiplication and a long subtraction every time we obtain a new digit in the partial quotient.

The method of Fourier, which is particularly applicable in such cases (i.e., when the divisor is large), consists essentially in rejecting all but the first few digits of the divisor, operating with them as a "partial divisor," and effecting appropriate corrections en route.

The utility of the procedure will be perceived, especially for engineering computation where a machine is not available.

The introduction to this country and the following presentation of the method (which is little known, and does not appear in the literature) are due to Uspensky. The rules follow.

1. Any number of digits may be selected for the partial divisor, but it is convenient to take only the first two or three. Divide in the ordinary manner by the partial divisor, obtaining the first remainder and then, by bringing down the next digit from the dividend, obtaining the first partial dividend.

2. It is now necessary to make a correction. Form the sum of the products of the last digit found in the quotient by the first digit following the partial divisor, of the second last digit found in the quotient by the second digit following the partial divisor, etc. This sum must be subtracted from the first partial dividend, obtaining the first *corrected* partial dividend.

3. Divide the corrected partial dividend by the partial divisor and append the next digit of the dividend. Make a second correction. This process is repeated until the complete quotient is obtained. The decimal point of the quotient is placed by inspection.

Example:

dividend	partial divisor	
9304.7651	8261.845	divisor
82	1.1262	quotient
110	first partial dividend	
6	first correction	
104	first *corrected* partial dividend	
82		
224	second partial dividend	
7	second correction	
217	second *corrected* partial dividend	
164		
537	third partial dividend	
21	third correction	
516	third *corrected* partial dividend	
492		
246		
50		
196		
164		
32,		

etc.

(*Continued on page 88*)

1. Your telephone in peacetime reaches 95% of the world's telephones and over 26,000,000 in the United States today.

2. You fly with greater safety because of radio telephony between plane and ground—demonstrated by Western Electric in 1917.

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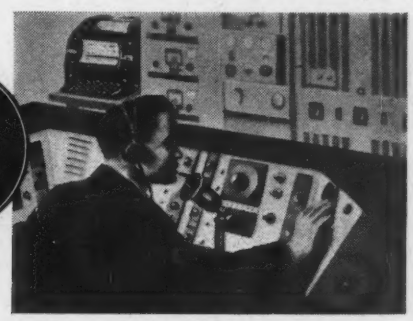

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6. You can enjoy talking pictures—made commercially possible back in 1926 by Western Electric development.

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Reports of Presidents are sometimes amazing in their content in that they not only present the aggregate of all reports on matters of major importance to the institution to which they refer but also give the views of the President on these and other matters. Much is to be learned from the study and analysis of such a report, not only as to what has happened since the submittal of the last one, but also as to what is planned for the future — the fulfillment of suggestions put forward by the last report and further needs to be cared for before the next report is due.

On October 11 of this year Karl T. Compton, President of the Institute, submitted his report, covering the period from October 1943 to October 1944, to the Corporation. Besides a résumé of the highlights of the past year, including financial, war research, enrolment and war training statistics, a definite plan of action for the future, under the title Post-War Program, was put forward, having as its main theme the acquiring of facilities for handling the large number of students expected to gain admission after the war. This number is expected to reach approximately 4500, including returning servicemen, during three post-war years and to drop to 3600 as a stabilized enrolment. It is easy to see that, if stabilized enrolment is the rule, new housing facilities are necessary. They have been planned for, along with the second unit of our ultimate gymnasium, the first unit of which is the Alumni pool, and a new library with expanded functions.

The most important and far-reaching step to be taken is the construction of the new library, the needs for which and the operation of which are here explained:

"Our Corporation's Visiting Committees on the Library and on Student Life have developed some highly significant plans for improving the cultural life of our students, on and off the campus. Numerous steps have in the past been taken in this direction, but have never achieved much more than minimum necessities. We could, if we handled it properly, add very greatly to the reservoirs of spiritual strength and the adjustment to social environment with which our graduates leave the Institute to enter their life's work.

"The Committee visualizes a new library building, located near the center of student traffic between Building 2 and the Walker Memorial and connected cleverly with both. It should contain the most modern facilities of the library art to give optimum library service, such as microfilm reproduction and viewing, and automatic selection and delivery of card catalogue information. In fact it might well become a pioneering, or try-out center for the ingenious mechanoelectrical aids in the storing and distribution of printed information whose development was just getting under way when the war broke out.

"In addition to being a great technological library serving M.I.T. students and staff and the New England region generally, the plan contemplates features that will make this library the cultural center of the institution. These include seminar rooms and headquarters for the Division of Humanities, attractive rooms for both study and recreational reading, music rooms, exhibition space for library and art treasures, including the remarkable Dard Hunter Paper Museum, and a little theater. Such facilities would contribute wonderfully to the wholesome enjoyment of college life by successive generations of students and to their education for enriched and well-balanced lives.

"Through several years of study, the Visiting Committee and its consultants have developed this plan. It is sound and thoroughly worth while. Its realization should now be recognized officially as one of the major objectives in the Institute's post-war program. As evidence of this recognition, the Executive Committee has very recently appointed Professor John E. Burchard to be director of the M.I.T. Libraries. He was the first chairman of the Friends of the Library. In his new post he will take the lead in developing more detailed objectives, assist in making this plan a working reality, and guide its program. Under him, the Librarian will continue to head the professional library service."

We think you will agree that college life at M.I.T. is not up to the standard set by many liberal arts colleges of the day, and certainly the cultural life is not. If the new library comes into being it will be a godsend to the Institute for this, coupled with the new curriculum which includes a four-year course in the Humanities, will tend to create engineers with a much broader social background than is now possible.

It does not always follow but in this case it will be worked on to make sure that the library contains complete information on every technological subject. Thus it can be seen that the post-war program put forward will definitely insure M.I.T. of its place as leading technological center of America and, possibly, of the world.

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HONORARY AND PROFESSIONAL SOCIETIES AT M. I. T.

TAU BETA PI

The Technology Massachusetts Beta Chapter of Tau Beta Pi enjoyed a delightful outing in the Blue Hills on Saturday, October 7. Beginning at 4.00 p.m. on the banks of Hoosicwhisic Pond, the picnic was highlighted by games and contests for the couples in the afternoon. When darkness approached, the group gathered around the fireplaces roasting hot dogs and then singing until nearly 9.00 o'clock. A perfect day was brought to a close by dancing back in Cambridge at the 5.15 Club.

On Monday, October 9, 1944, the last business meeting of the term was held. The following officers were elected for the coming term: President, William F. Blitzer; Vice-President, Robert E. Wilson; Corresponding Secretary, Donald A. Buell; Recording Secretary, Walter Levy; Treasurer, Roderick Harris; Cataloger, Edward C. Holt.

ALPHA CHI SIGMA

At a recent meeting of Alpha Zeta Chapter of Alpha Chi Sigma Dr. Williams gave an interesting address to the Society on the subject "Magnesium."

The Society held its last meeting for the term on October 4 in the Moore Room. At this time election of officers for the fall term were held. Those so honored were: Harold Thorkilsen, President; David A. Tragesser, Vice-President; James L. Gurney, Treasurer; Gonzalo C. Docal, Corresponding Secretary; David M. Rock, Recording Secretary; Arthur L. Hall, Chairman of the Entertainment Committee; and Robert F. Petzold, Master of Ceremonies.

INSTITUTE OF THE AERONAUTICAL SCIENCES

The M. I. T. Chapter of the I. Ae. S. has completed a very successful year. The organization has grown from less than twenty members last February to its present enrollment of nearly fifty. Despite wartime restrictions various activities have been carried on in the form of lectures and dinner meetings. The recent growth of Course XVI has emphasized the importance of the I. Ae. S. as a means of introducing the student to the aeronautical profession. The national organization is the most important of its kind in America and has as its president an M. I. T. graduate, General Jimmy Doolittle, '24.

The Society is looking forward to an interesting series of programs during the winter and spring.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

The Chapter's last meeting for the term was held on October 3, at which time a film entitled, "Rubber Reborn" was shown. The film described the processes involved in the processing of used rubber tires into reconditioned rubber.

Elections for the coming term were also held at this meeting. The new officers are: Homer Elliott, President; Christopher G. Boland, Vice-President; Hyman W. Fisher, Secretary; and Nelson Chang, Treasurer. Dr. Broughton, the faculty advisor, welcomed the new officers to their posts.

On November 17 Professor Hauser gave an interesting address to the society on the subject, "Applications of Theory to Practice in Science."

Plans for an active program this coming term include movies, speeches, plant trips, and outings.

The retiring officers, Robert Horrigan and Charles Sollenberger, were accorded a vote of thanks.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

The M. I. T. student branch of the American Institute of Electrical Engineers completed the summer term with a picnic and a talk by Dr. A. P. T. Sah, President of the University of Amoy, now at Chang-Ting, China.

The Course VI (A. I. E. E.) picnic was held at Riverside, Mass. on September 17 and was attended by about twenty-five students, their dates, and several members of the Faculty. Outdoor sports were featured in the afternoon and a picnic supper was prepared and served in the evening.

At the October 3 meeting Dr. A. P. T. Sah, noted Chinese educator and electrical engineer, spoke on the subject "Chinese Engineers at War." His talk was extremely interesting and timely because of the present trends of World War II. He discussed the potentialities of the Chinese engineer and his need of assistance from the rest of the world.

The fall term brings with it a new set of officers — George Lawrence, Chairman; Charles Hooker, Vice-Chairman; Robert Fauvre, Secretary; and L. C. Wellard, Treasurer. At this time their plans for an active semester are being formulated. Arrangements for a technical paper contest are being considered as one of the term's activities.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

On September 29 and October 6, the student branch of the American Society of Mechanical Engineers in coöperation with the A. G. C. and the Architecture Society presented two lectures on the subject of "The Post-War Home."

Professor Voss, head of the Department of Building Engineering and Construction, presented the first talk on the subject of "Financing the Post-War Home." Professor Voss emphasized that it is every man's duty to own his own home as soon as it is financially practical.

Professor Adams, head of the City Planning Course, was the second speaker in the series. His subject was "The Post-War City."

The Society finished the school year with a dinner meeting held at the Smith House. The principal speaker was Professor Timbie of the Electrical Engi-

(*Continued on page 84*)

SERVICE STATION *on the road to Tokyo*

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(Continued from page 82)

neering Department. Included in the program was a repetition of the prize winning speech of the A. S. M. E. speaking contest. The winner was Thomas A. Hewson, who spoke on the Rosette Strain Calculator.

The officers elected at the meeting for the next academic year were: Warren J. Harwick, Chairman; William J. Meade, Vice-Chairman; William J. McKay, Secretary; and Harold V. Rover, Treasurer.

PHYSICS SOCIETY

The M. I. T. Physics Society, whose purpose is to promote interest in physics among the student body, was recently reorganized, fulfilling a long-felt need. Its business is now being carried on by a committee representing all the classes at the Institute; elections will take place next term as soon as a new constitution can be written and approved. So far the Society has presented talks by Dean Harrison on "Physics and the War," and by Professor Mueller on "Experiments on Polarized Light." Interest in the Society's work was evidenced by the large attendance at both of these lectures. Membership in the Society is open to all M. I. T. students who are interested in physics and at the same time would like to gain the experience to be had by working in the Society. Having already attracted over thirty members, the Physics Society is planning an even more ambitious program for next term. In addition to presenting lectures by men respected in their field, the Society hopes in addition to arrange a more informal program consisting of tours, smaller seminars, and the like.

THIS IS M. I. T. — METALLURGY

(Continued from page 71)

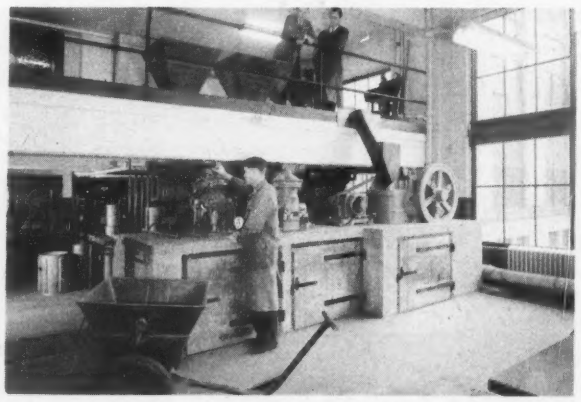
either a man's chief interest or his probable career after graduation, emphasis on professional work is equally divided among the fields of mineral dressing, which deals with the preparation of the ore for subsequent metallurgical treatment; process metallurgy, which includes fire refining, electrometallurgy and other methods for the production of the metals; and physical metallurgy, which in this year is restricted primarily to the thermal and microscopic study of metals and alloys.

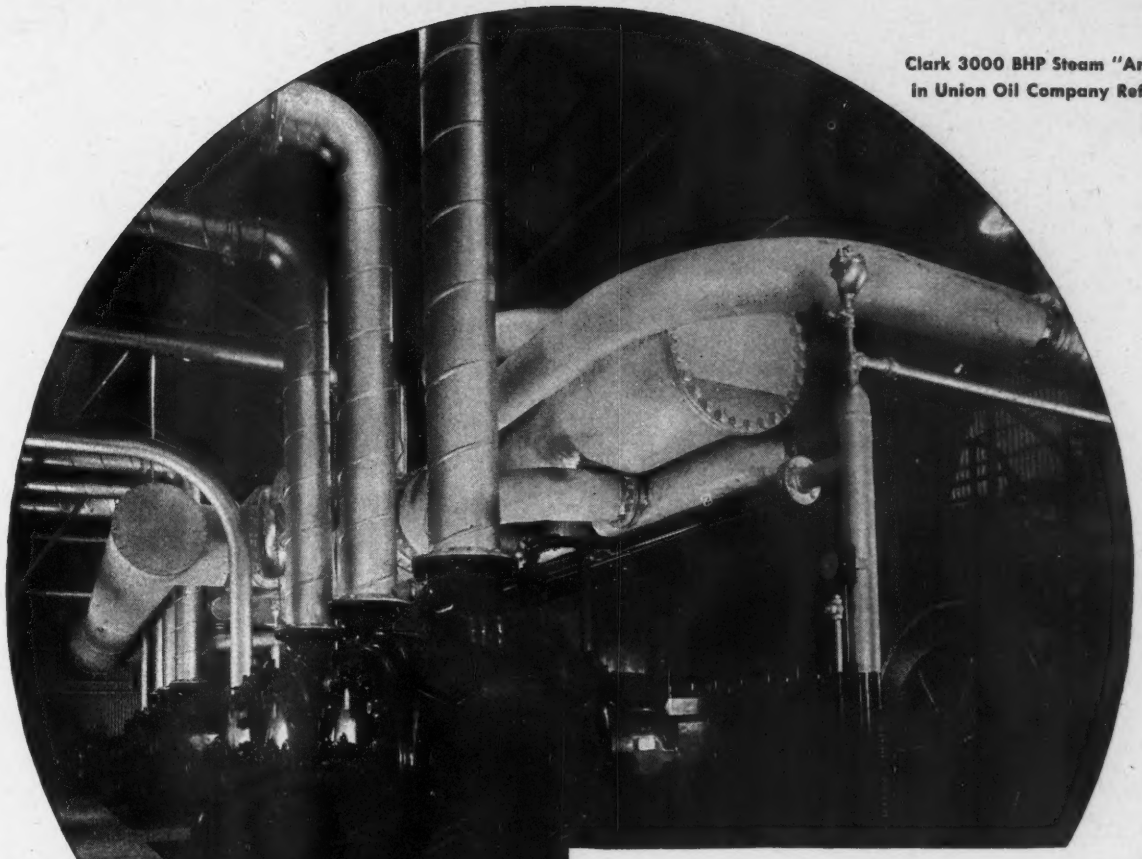
In the fourth and graduate years the intensity of specialization becomes greater with the chief emphasis on one of the three divisions of Metallurgy. At no time, however, is the specialization exclusive, for even when a student is a candidate for the degree of Doctor of Science in Metallurgy, he must still prepare for examinations in all three branches although, of course, his principal examination and his research will be limited to one field of interest.

It is evident that opportunities for the metallurgist are very great when it is realized that wherever a metal is used the metallurgist has at some stage been concerned with its production or development. A few illustrations will indicate the profound effects of the metallurgist's work on civilization. His invention of high speed tool steel caused a revolution in machine shop practice and that was followed by the production of Carboloy, still further increasing cutting speeds and making possible the machining of many materials that were previously shaped by grinding. The development by the metallurgist of the alloy duralumin, which is as strong as boiler steel and weighs only one-third as much, has made the modern airplane possible. The advantages of stainless steel, another metallurgical discovery, are too well known to need further comment. These are only a few of the metallurgical advances of the last fifty years.

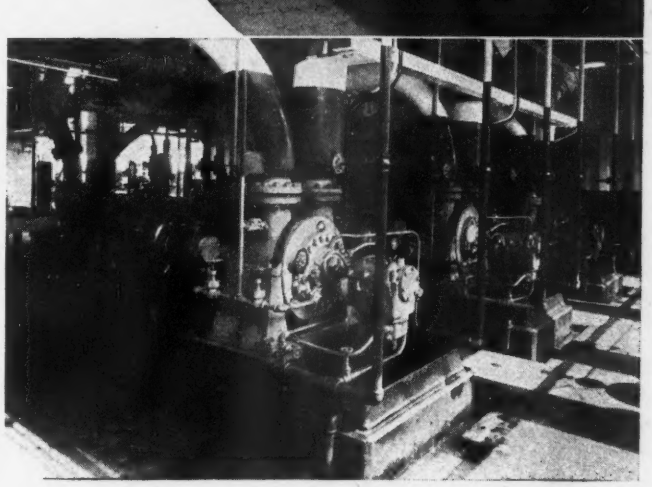
Civilization has passed through the Stone Age, the Age of Bronze, the Age of Steel and is emerging into the Alloy Age. In this development the metallurgist must share to an ever increasing extent.

In the newly designed Richards Mineral Dressing Laboratories, large lumps of mine-run ore are crushed to the size of sea sand and finer, in three successive stages involving the three crushers shown from right to left. The ore is handled in 600-pound hoppers, one of which, mounted in an "ore buggy," graces the foreground. The collecting hoppers are enclosed in the foundation beneath the crushers. This enclosure and the maintenance of a positive down draft of air through the crushers provide exceptionally clean and dust-free operation.





Clark 3000 BHP Steam "Angles" in Union Oil Company Refinery



Battery of Pacific Type HV Centrifugal Pumps

This battery of Pacific Type HV centrifugal pumps are delivering peak efficiency in refinery stabilizer reflux service. Type HV handles extremely hot or sub-zero liquids at low pressures, with speeds up to 3600 r.p.m., capacities 100 to 3000 g.p.m. and differential pressures up to 325 p.s.i. It is one of the many types of high precision pumps designed and built by Pacific.

In pump engineering achievements, Pacific has always anticipated and met the requirements of industry and takes pride in its long list of "firsts" in design, methods and construction.

Achievements in the Field

TWO Clark 3000 BHP Steam "Angles" and three 1000 BHP Gas-Driven "Angles" in Union Oil Co., at Oleum, Calif. . . . are serving in two important ways in making Hi-Octane gasoline.

Gasoline is being converted into Toluene by Catalytic cracking. The 2 Clark 3000 BPH Steam-Driven "Angles" furnish compressed air to burn coke, tar and asphalt from the catalyst keeping it in efficient operation. A gas residue is then compressed by the 3 Clark 1000 BHP super-charged gas-driven "Angles" to recover 8 to 15 additional gallons of highest grade gasoline per 1000 ft. of residue gas.

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Okonite's general catalog on wires and cables contains information on conductors and coverings, materials and fabrications, and a selector chart. Engineering students may obtain a free copy of this booklet by writing for Bulletin OK-1011. The Okonite Company, Passaic, New Jersey.

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GAS TURBINES

(*Continued from page 73*)

fuel but so far have proved unsuccessful. Experiments have been under way in Europe for some time to burn pulverized coal under pressure and to separate the solid residue of combustion before leading the gases into the turbine. Favorable results have not yet been obtained.

Until a solution of this problem has been reached, the gas turbine will have a hard time competing with other stationary power-generators. However, some of its other advantages may tend to compensate for this fault, especially in localities with short water supplies or where space is at a premium.

Marine power plants for both naval and merchant vessels also appear to be a very favorable field for the gas turbine. The gas turbine has an advantage over the steam turbine in that the former has no boiler to take up space and needs no heavy condenser or apparatus for distilling feed water. The gas turbine is much more compact than its competitors. Existing commercial marine engines — steam turbines, reciprocating steam engines, and Diesels — have a weight range of 100 to 300 pounds per horsepower, while the gas turbine, including a drive mechanism, will weigh only 40 to 50 pounds per horsepower. Before gas turbines can be used successfully in connection with marine transport, however, a satisfactory reversing gear must be developed. Gas-turbine engines burn cheaper fuels than do the Diesels and some saving may be looked forward to in that respect.

One of the most promising fields for gas-turbine application is in the design of gas-turbine-operated locomotives, where the gas-turbine engine would have many advantages over the steam and Diesel engines used at present. In steam locomotives, lubrication costs may amount to as much as ten per cent of the fuel costs. The gas turbine, consisting entirely of rotating machinery, will cost less to lubricate and maintain than either steam or Diesel, the initial costs will be less than Diesel, and there will also be a saving from the cheaper type of fuel which the gas turbine can burn.

Perhaps the most intriguing of the gas turbine's potentialities is the part it may play in the recent exciting aircraft development — jet propulsion. The gas turbine, as applied to jet propulsion, constitutes what is called the turbo-jet engine. As the airplane moves forward, air enters the front of the streamlined engine cowling and is compressed by an axial-type compressor, from whence it is passed on to a ring of combustion chambers where it is ignited with a continuous jet of a liquid fuel such as common kerosene. The hot, expanding gases force their way out through a somewhat constricted rear outlet and in so doing turn a turbine wheel whose purpose is to supply power to the compressor. The jet of gases emerges from the engine with great force, and the reaction to this force drives the plane forward through the air.

Today in the United States and in other countries all over the globe, men are working on the gas turbine: smoothing out its faults, developing its potentialities, and ever seeking new ways to apply it to the service of mankind. Here at the Massachusetts Institute of Technology, there is a course, soon to be extended to eight hours a week, devoted to the study of gas turbines and their applications. The first part of the course takes up the theory and development of the gas turbine; then in the later part of the course, each student must design a compressor, a turbine, and a regenerator. The purpose of this course, new at M. I. T., is to give to

(*Continued on page 88*)

A Million Jobs are Waiting

. . . for the Hardest *Metal* Made by Man

Starting as a metal powder, Carboloy Cemented Carbide is transformed, under heat and pressure, into an endless variety of shapes and forms—tool tips, dies and machine parts with the super-hardness that is vital to high-speed, low-cost industrial production.

STRAIGHT through industry, after the war, there will be jobs that only the "hardest metal made by man" can handle.

Why? Because the cry is for better, longer lasting products and parts. Because closer tolerances will be combined with mass production.

And because industry knows that postwar profits will depend largely on the cost at which goods of top quality can be produced in top volume.

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Urgent war production needs brought Carboloy Cemented Carbide into its own. Its *super-hardness* was needed in tools to machine *super-tough* alloys—in dies to draw wire and tubing and to form sheet metal.

Carboloy Cemented Carbide works at speeds once thought impossibly high, to tolerances never before practical in mass production—and it commonly doubles or triples the output of machines and men.

It is a matter of war record that the use of this magic metal made possible production of three times the number of aircraft engine crankcases and gears with the same equipment and manpower. And this is only one of many examples.

In peacetime production, it is certain that the usefulness of Carboloy Cemented Carbide will be greatly expanded, in widely varied fields—not only for tools and dies but for "wearproofing" parts that must stand up under modern machine speeds and stresses.

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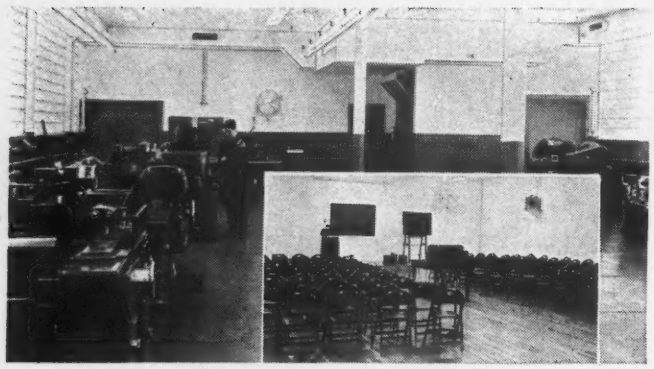

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GAS TURBINES

(Continued from page 86)

those men who desire it the chance to learn more about this new source of power.

This training of young engineers in the operation of the gas turbine is a good indication of the importance attached to this engine's future development. As advances are made in metallurgy and aeronautics, and the operating temperature and the general over-all efficiency are increased, the gas turbine will prove to be one of the greatest discoveries in man's search for power.

FOURIER DIVISION

(Continued from page 78)

This process suffices unless a corrected partial dividend is negative after correction. To cover this possibility, it is necessary to observe these additional rules:

4. If a correction gives a negative corrected partial dividend, the last digit obtained in the quotient must be diminished by one unit.

5. To the negative corrected partial dividend must be added ten times the partial divisor plus the sum of as many digits following the partial divisor as there are digits in the quotient which underwent change.

If successive partial dividends are negative, it is possible to avoid the somewhat bothersome corrections necessitated thereby, by passing to a larger partial divisor. It is also possible at any stage to discover the true remainder. These two cases are covered by this final procedure.

6. To pass to a larger partial divisor, the corrected partial dividend is obtained as usual. Then the next digit of the dividend is appended and *another* correction is made with the *new* partial divisor. Division is then continued with the larger partial divisor.

7. The true remainder may be obtained at any stage of the division by appending a new digit of the dividend and making a correction, appending the next digit of the dividend and making another correction, etc., until the correction becomes zero. This last remainder will be the true remainder of the division.

8. The last digit obtained in the quotient is correct if either the remainder or corrected partial dividend is not less than the sum of the digits of the quotient.

Example:

dividend			
316567899	23786554	divisor	— first partial divisor
23	133086	quotient	⌒ second partial divisor
—			
86			
7			
—			
79			
69			
—			
105	2d part. div.		
29	2d corr.		
—			
76	2d corr. part. div.		
69			
—			
76			
51			
—			
25			
23			
—			
27	4th part. div.		
54	4th corr.		
—			
−27	4th corr. part. div.		
+237	correction for negative partial dividend		
—			
210			
207			
—			
38	5th part. div.		
101	5th corr.		
—			
−63	5th corr. part. div.		
+237	correction for negative partial dividend		
—			
1749	change to larger partial divisor		
98	correction with *new* partial divisor		
—			
1651	new partial dividend		
1422			
—			
2299,			
	etc.		

When, by a little practice, a reasonable facility is developed, the process will be observed to be greatly superior to the conventional method for long division in the saving of both time and arithmetic labor.

The Fourier method of division may also be extended to facilitate the extraction of roots.

MOISTURE

the enemy of radio insulators

CAN'T PENETRATE STEATITE

Moisture in hot steaming jungles and in cold foggy climates is a life-shortening enemy of radio equipment.

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The low loss factor, the high physical strength, the stability of shape of Steatite is not affected by age or climatic changes. For a long trouble-free life of your equipment specify Steatite Insulators made by General Ceramics & Steatite Corporation.

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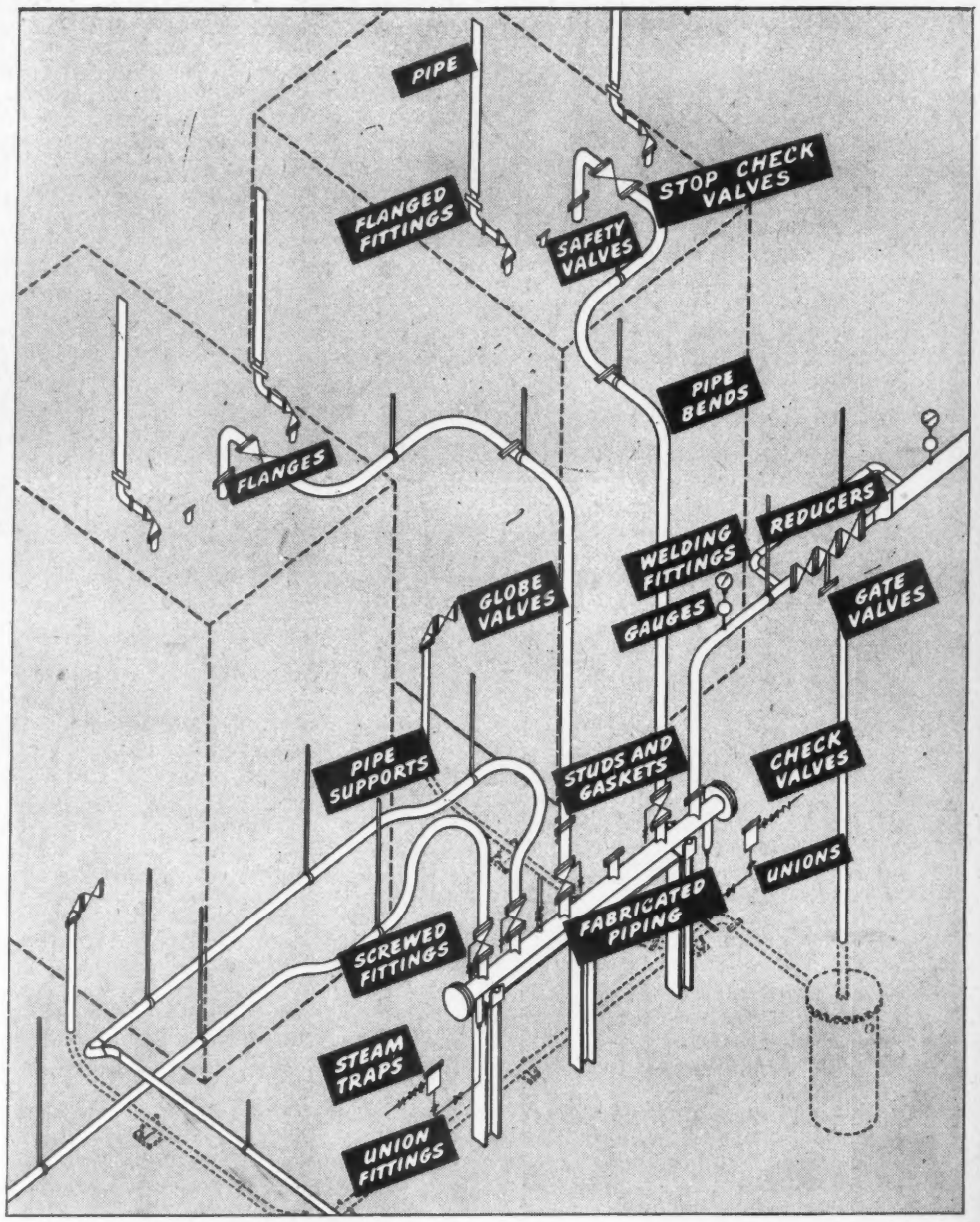
IT TAKES PIPING TO MAKE IT WORK



WHETHER it is a hydro-electric plant or an oil refinery—a water works or a steam power line—a cargo ship or a refrigerating system, or any of hundreds of other engineering projects that you can mention—piping controls the flow of air, water, oil, steam and gas that are so necessary to their operation.

And piping means more than a line on the blue print—it means lengths of pipe of the correct diameter—it means valves and fittings and traps and joints—it means flanges and cocks and gauges and floats of the proper sizes and proper types to assure the maximum service for the system you are designing.

But many and varied as are the parts of the piping system, it will interest you to know that they are all included in the complete Crane line.

And when it comes to writing specifications, you will find what many engineers before you have discovered: that by specifying "Crane" for the whole system, you are assured of matched piping with all parts designed to work together, plus the long life and low up-keep that mean efficient, satisfactory service.

HERE'S DATA TO HELP YOU

Crane engineers have prepared a number of important books and treatises on piping equipment and piping systems. These include the Crane Catalog, *listing more than 48,000 different piping items and containing valuable engineering data*—Piping Pointers Manual, *packed with information on piping installation and maintenance*—Flow of Fluids *and* Combating Corrosion, *two technical papers of value to anyone laying out pipe lines.*

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These chemicals are manufactured in large quantities by CARBIDE AND CARBON CHEMICALS CORPORATION. Uncolored, they are water-white. To the chemists, who must know what they will do in your car, they are compounds of carbon, hydrogen and oxygen, the atoms of which are shown here in the molecular models.

ETHYLENE GLYCOL, ETHANOL and METHANOL are the bases of anti-freezes—and they help to take one of the worries out of winter for millions of motorists.

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"Prestone" ethylene glycol-base anti-freeze. One "shot" gives all-winter protection.

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"Blue-Flo" ethanol-base anti-freeze. Not being manufactured this year because ethanol (ethyl alcohol) has a bigger war job to do.

Certain other anti-freezes formulated and manufactured by Units of UCC for large national distributors.

"Rustone" corrosion preventive which, when added to the water in a clean cooling system, inhibits the formation of rust.

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Car owners are invited to send for the booklet P-11, "Manual of Cooling System Service." It will be sent without cost or obligation.

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The duration of each of the above undergraduate Courses is four academic years, with the exception of Architecture, Physical Biology, and the co-operative Courses in Electrical Engineering and in Mechanical Engineering, which extend over a period of five years, and City Planning Practice which covers a period of six years. In addition to the Bachelor's degree, the above five and six year Courses, with the exception of Architecture, lead also to the Master's degree.

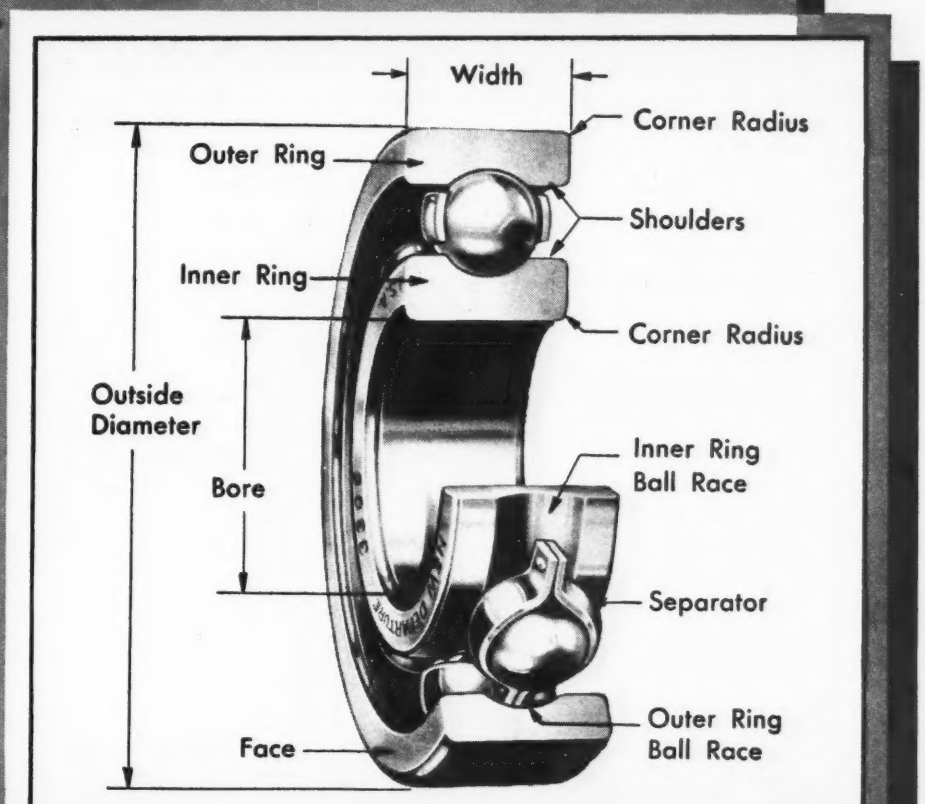
Graduate study, leading to the Master's and Doctor's degrees, is offered in Ceramics, Meteorology, and in most of the above professional Courses.

A five year Course is offered which combines study in Engineering or Science, and Economics. This leads to the degree of Bachelor of Science in the professional field, and to the degree of Master of Science in Economics and Engineering or Economics and Natural Science.

For information about admission, communicate with the Director of Admissions.

The Catalogue for the academic year will be sent free on request.

Ever wonder about the anatomy of a Ball Bearing?



The subject of the Ball Bearing is on everyone's lips nowadays, because of its immense importance to the prosecution of the war.

But how many know what a ball bearing is—what it does—why it is so indispensable?

A ball bearing is not merely a steel ball! It consists of the assembled mechanism illustrated.

It is used wherever shafts turn, to support loads, to permit higher, smoother speeds. Because nothing rolls like a ball, it reduces friction and wear and assures that the precise "location" of machine parts is maintained.

To those who would know more about this "tremendous trifle" we offer free an interesting 112 page book entitled, "Why Anti-Friction Bearings?"

nothing rolls like a ball

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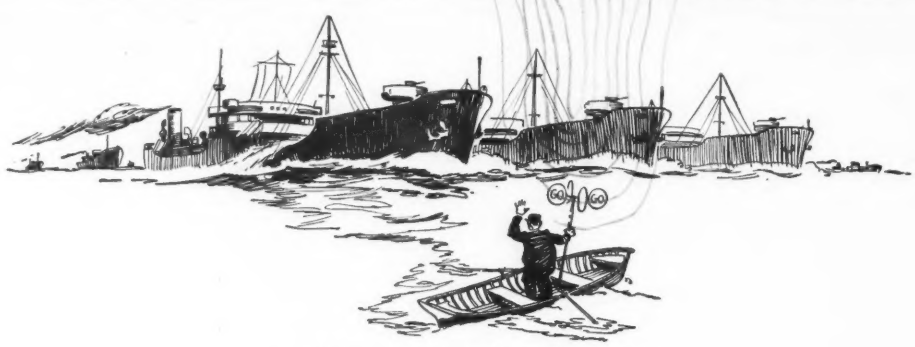
G-E Campus News

RESEARCH AND ENGINEERING KEEP GENERAL ELECTRIC YEARS AHEAD

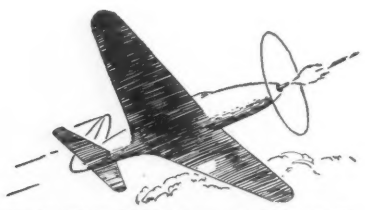


TANKERS ON PARADE

IT would take 1,900 miles of tank cars to equal the capacity of all the tankers built since Pearl Harbor which are powered by General Electric propulsion equipment. At any rate, that was the figure through July of this year.

General Electric first built turbine electric drives for the Navy in 1909. Chief advantages then and now have been speed and efficiency. In wartime these are especially important. Tankers must move fast to keep up with the swiftest ships in the fleet, keep ahead of enemy subs, and utilize their carrying space fully.

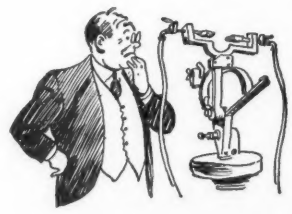
General Electric is building three-quarters of the drives for the high-speed tankers ordered by the Maritime Commission since the United States entered the war. Speed of the 6,000-hp tankers is better than 15 knots, the 10,000-hp ones can do over 17 knots—both are considerably faster than a submerged submarine. The new high-speed tankers move fast enough and are sufficiently armed to run free on the long treks across the Atlantic and the Pacific. They no no longer wait for convoys.



DOUGHNUT MOTOR

IN the nose of some fighter planes, right in the middle of the motor that feathers the propeller, is a 37-mm cannon. Building a motor with a hole where the shaft ought to be was a brain twister, but G-E engineers solved this problem with an electric motor shaped like a doughnut.

The motor which automatically changes the angle of the propeller blades as flying conditions change has been designed with a hollow shaft. It is one of the many unusual motors that General Electric has designed and built to meet some specific need of America's fighting men.



BRAIN CHILD

ALMOST everyone likes to experiment now and then. It's fun, and in addition, worthwhile results are sometimes obtained. There is one machinist at the General Electric plant in Bridgeport whose experimenting brought real results recently.

The device shown above is his brain child. It may look a little grotesque, but it has proved very useful. A brazing fixture which can be rotated around three different axes, it has speeded up production on ignition parts for aircraft and earned a $750 cash suggestion award for the inventor. ***General Electric Co., Schenectady, New York.***

Hear the General Electric radio programs: "The G-E All-girl Orchestra" Sunday 10 p.m. EWT, NBC—"The World Today" news, every weekday 6:45 p.m. EWT, CBS.

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